

UNCLASSIFIED I

Mach 3 Legend

Design and Development of the Lockheed Blackbird



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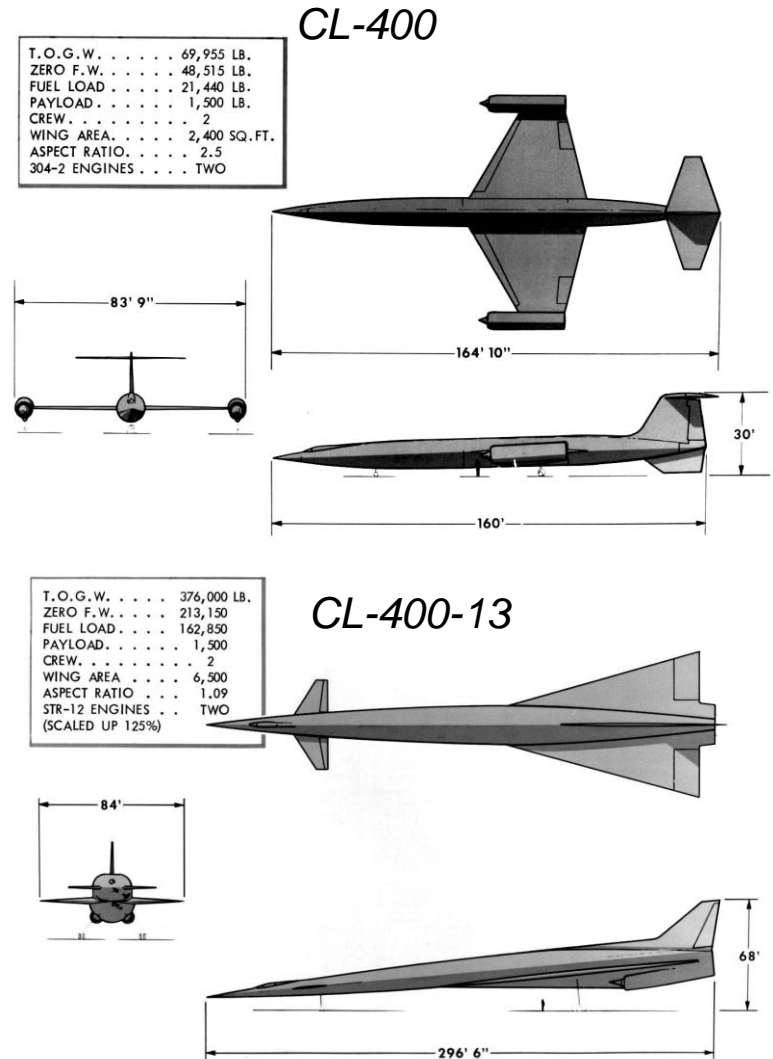
U-2: PROJECT AQUATONE



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PROJECT SUNTAN

- USAF initiated a U-2 successor in late 1955
 - *Liquid hydrogen fuel*
 - *Mach 2.5, 100,000 ft altitude*
- Operationally Impractical
 - *Limited range with no growth*
 - *Need for worldwide basing with cryogenic storage facilities*
 - *“Kelly” Johnson recommended cancellation in March, 1957*
- Follow-on Studies initiated in February, 1958
 - *Lockheed, Boeing, Convair, North American participated*
 - *None of the studies showed promise*
 - *Program terminated in Feb '59 by mutual agreement*



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PROJECT GUSTO



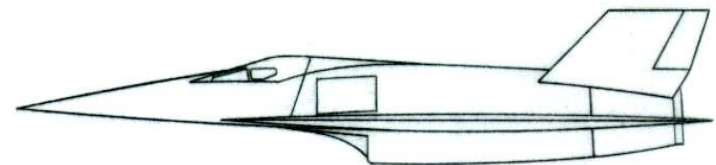
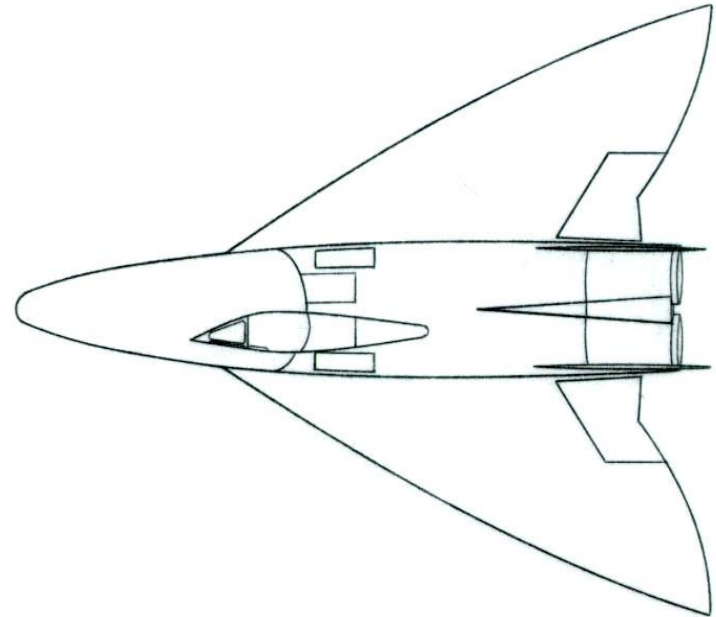
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Convair FISH

Cruise Mach Number: 4.2
Cruise Altitude: 90,000 ft
Range: 3,900 NM
Span: 37.0 ft
Length: 48.5 ft
Height: 9.8 ft

Propulsion:
Two “pop-out” J85 turbojets for
landing
Two Marquardt ramjets for cruise

Launched from B-58 at Mach 2.2
above 35,000 ft



Convair KINGFISH

Cruise Mach: 3.2

Cruise Altitude: 85 - 94 kft

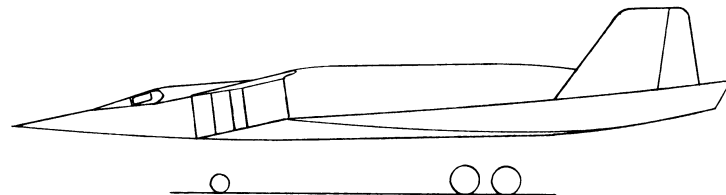
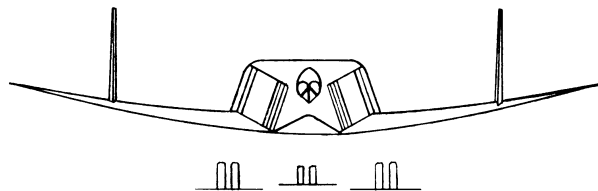
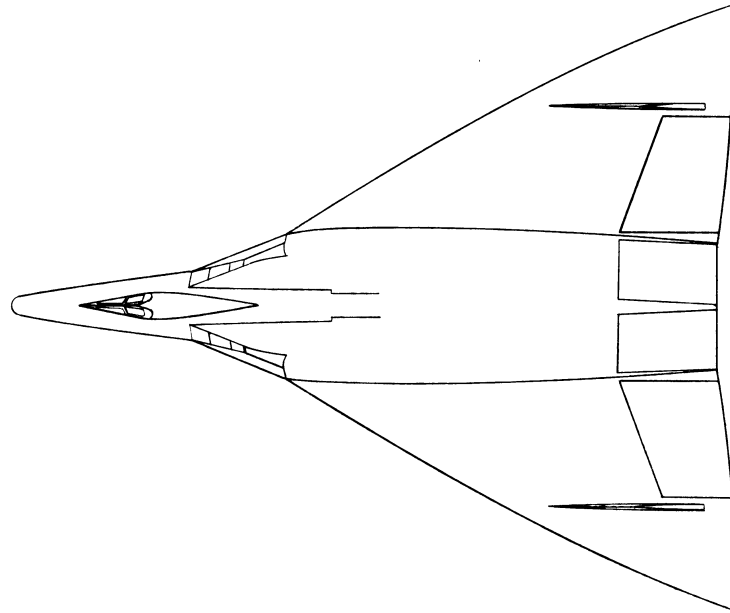
Total Range: 3,400 NM

Powerplants: Two J58 w/AB

Length: 73.6 ft

Span: 60.0 ft

Height: 18.3 ft

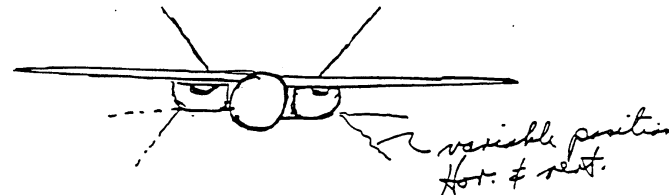
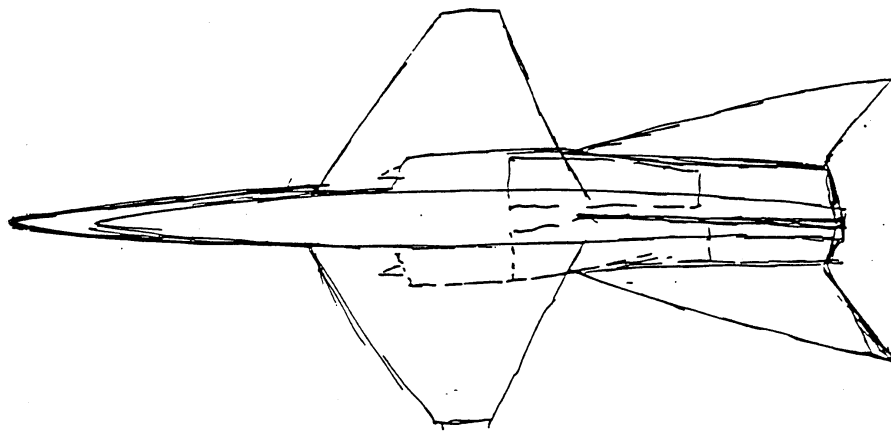


Original U-3 Design Concept - April 1958

Page 5.

April 23

Payload: 500 lbs
Range: 2,000 NM
Altitude : 100,000 ft.
Cruise Speed: Mach 3.0
RCS: Minimal



KEY ENABLING TECHNOLOGIES

- B120-VCA titanium alloy
 - Enable conventional stiffened structure Vs honeycomb/sandwich
- Pratt and Whitney J58 turbojet
 - Sustained high Mach cruise
- Mixed Compression Variable Geometry Inlets
 - Maximize inlet recovery across flight envelope
- Ramjets
 - Enhanced high altitude/high Mach performance
- Advanced Fuels
 - JP-150 (low vapor pressure, stable over wide temperature range)
 - “High Energy Fuels” (pentaborane, ethyldecaborane - 35% increase in energy content per unit mass versus JP150, but highly toxic)
- Relaxed Static Stability
 - Minimize trim drag during cruise

DESIGN TOOLS - 1958

- Slide Rule (routine calculations)
- Friden mechanical calculator (stress analysis)
- IBM mainframe computer (method of characteristics)
- Component level/assembly level aerodynamic & structural tests

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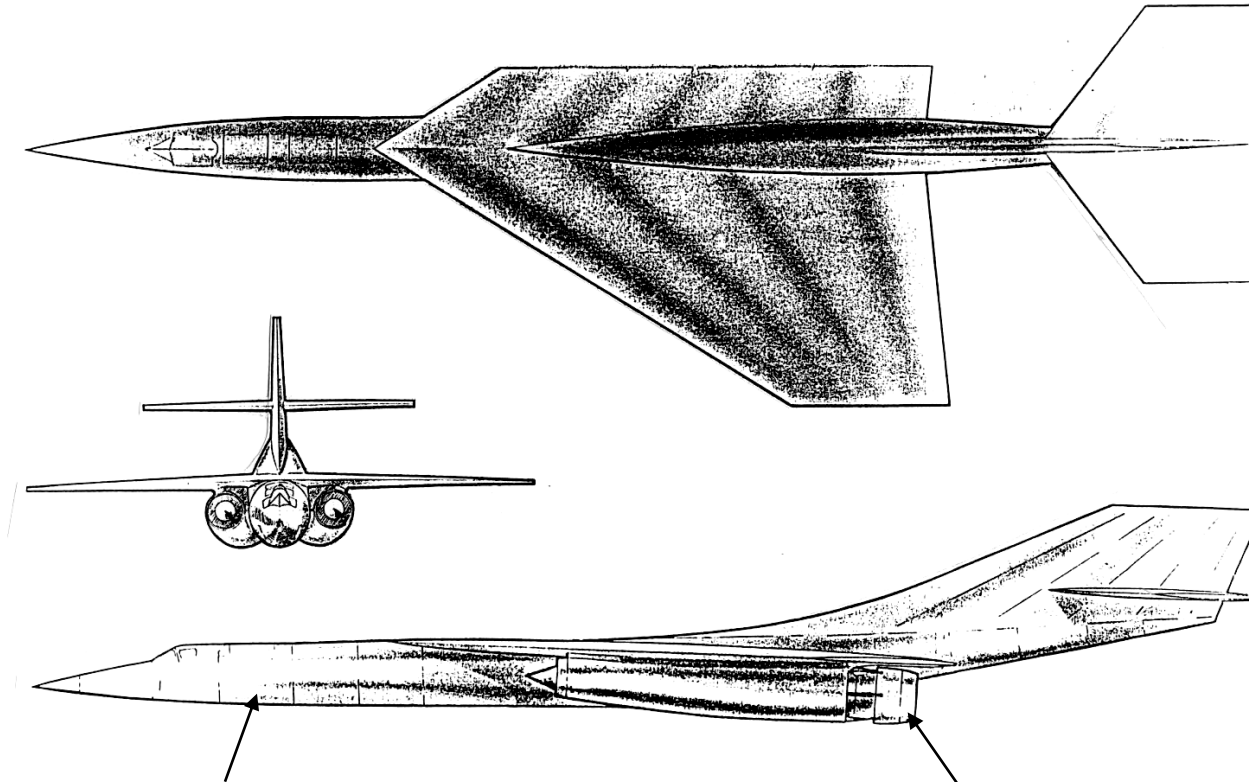
ARCHANGEL 1

July 1958

Length: 116.67 ft
Span: 49.6 ft
Height: 23.58 ft

Zero Fuel Weight: 41,000 lbs
Fuel Weight: 61,000 lbs
Takeoff Gross: 102,000 lbs

Cruise Mach: 3.0
Cruise Alt: 83 - 93 kft
Radius: 2,000 NM



500 -lb Q-bay payload

B120VCA titanium structure

J58 turbojets/JP-150 fuel

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A-2

September 1958

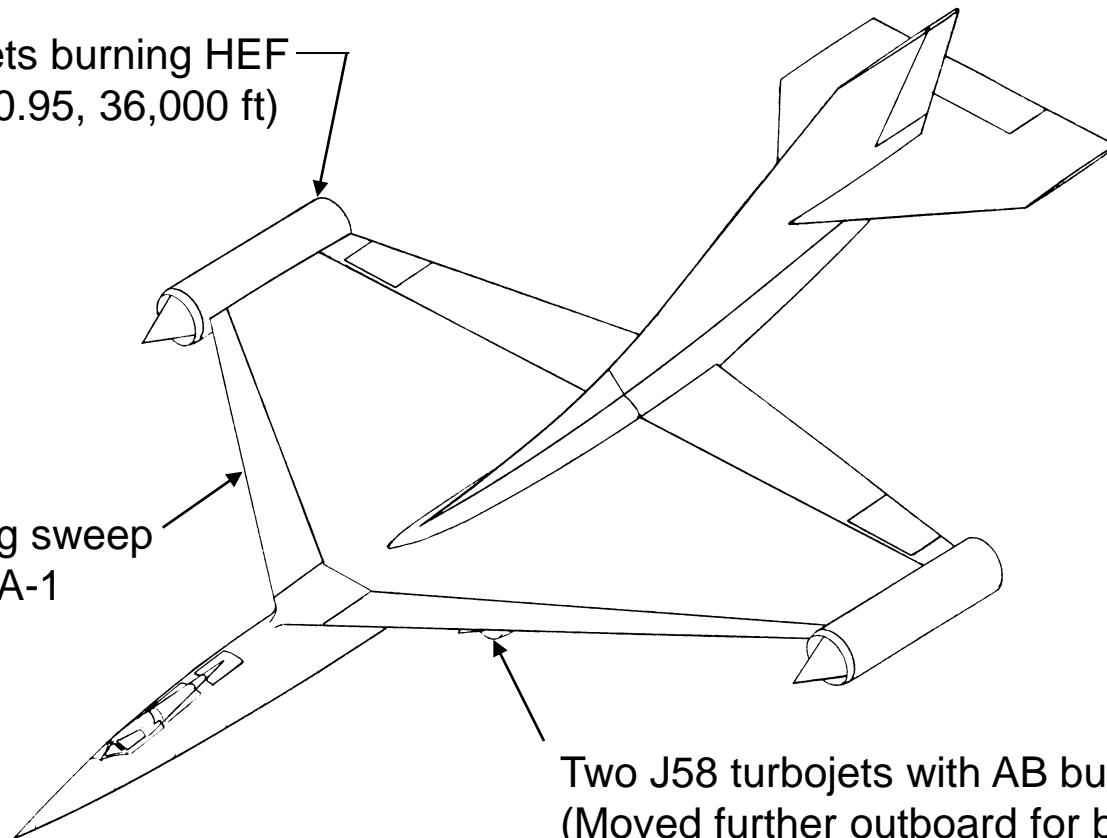
Length: 129.17 ft
Span: 76.68 ft
Height: 27.92 ft

Zero Fuel Weight: 54,000 lbs
Fuel Weight: 81,000 lbs
Takeoff Gross: 135,000 lbs

Cruise Mach: 3.2
Cruise Alt: 94 -105 kft
Radius: 2,000 NM

75" dia ramjets burning HEF
(Lit @ Mach 0.95, 36,000 ft)

Reduced wing sweep
compared to A-1



Two J58 turbojets with AB burning JP-150
(Moved further outboard for bending relief)

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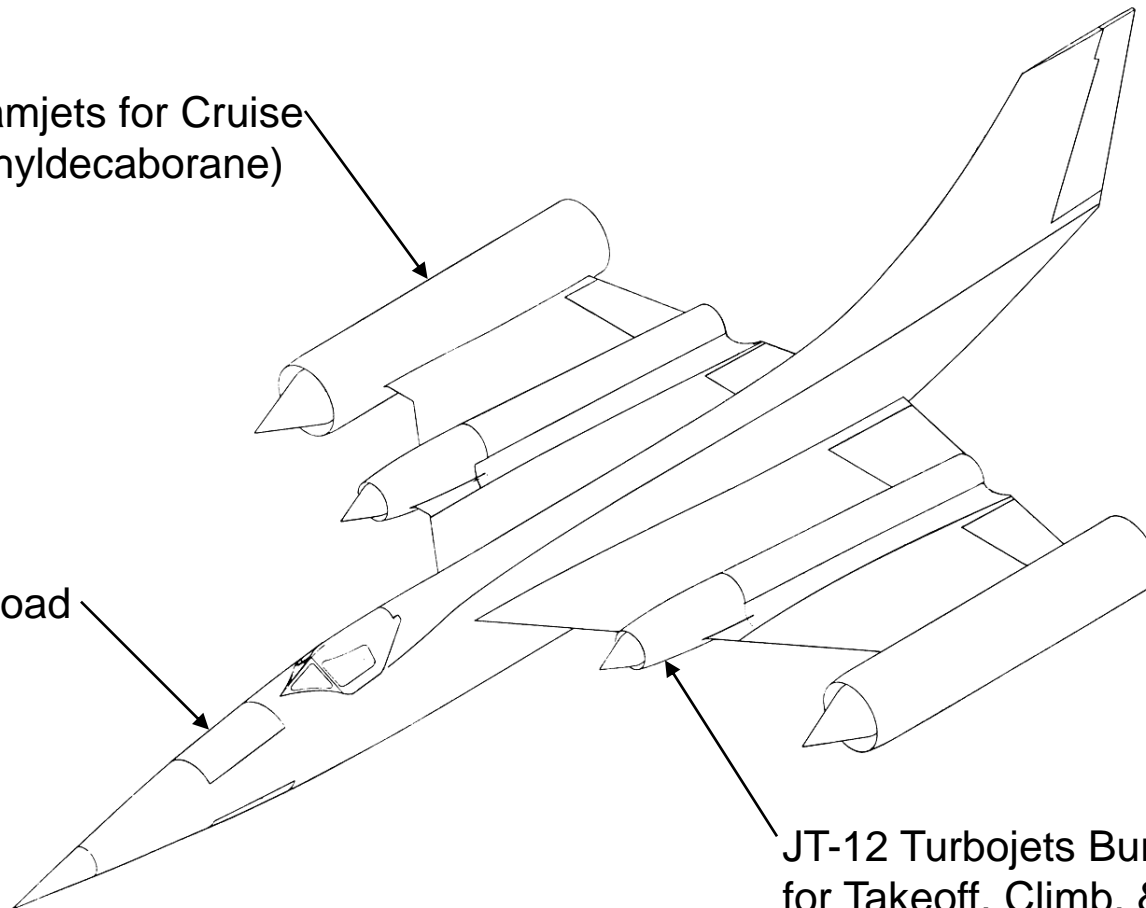
A-3

November 1958

Length:	62.3 ft	Zero Fuel Weight:	12,000 lbs	Cruise Mach:	3.2
Span:	33.8 ft	Fuel Weight:	2,600 lbs	Cruise Alt:	95 kft
Height:	14.6 ft	Takeoff Gross:	34,600 lbs	Radius:	2,000 NM

40" Dia. Ramjets for Cruise
(Burning ethyldecaborane)

250-lb Payload



JT-12 Turbojets Burning JP-150
for Takeoff, Climb, & Acceleration

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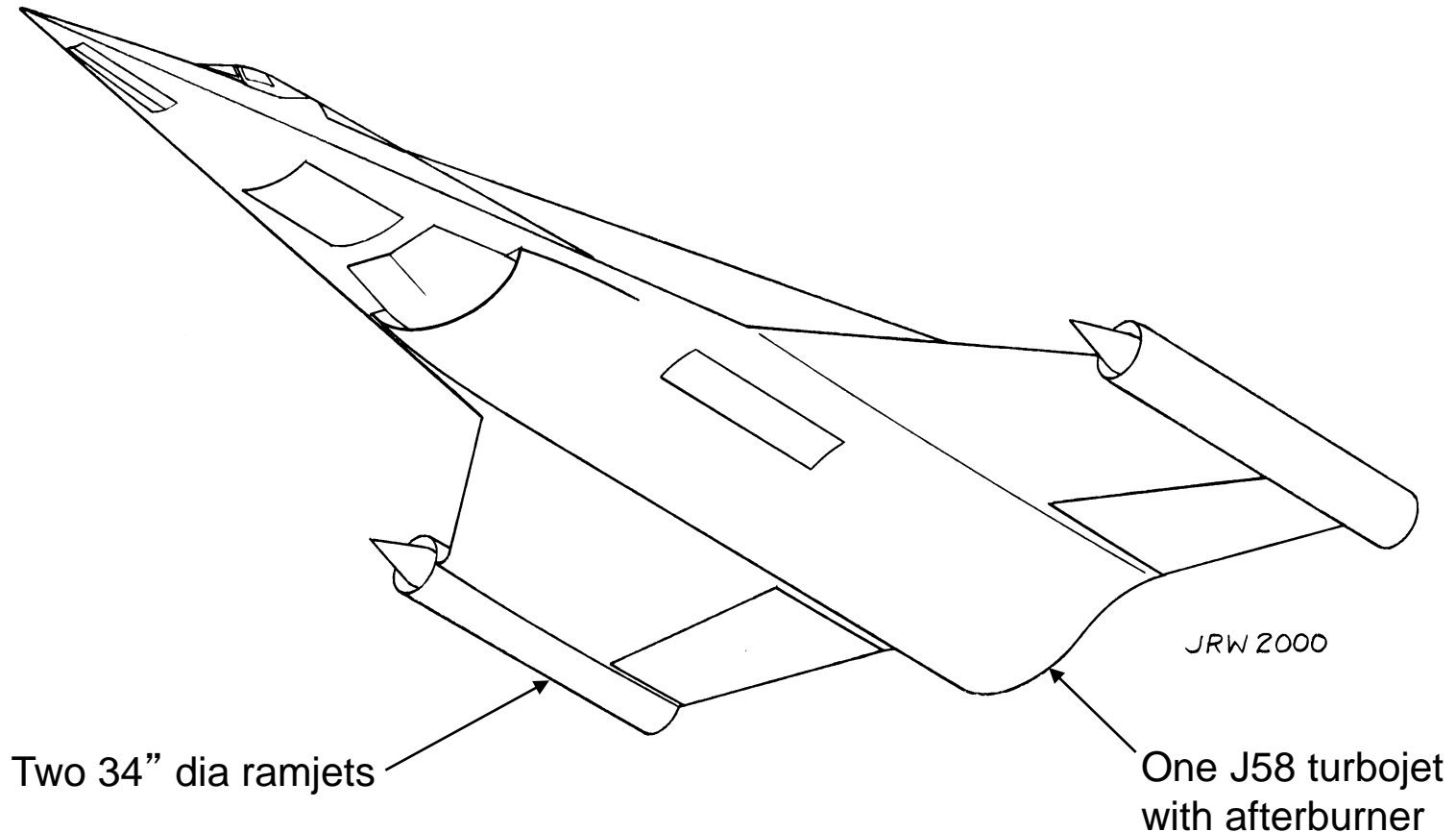
A-4

December 1958

Length: 58.33 ft
Span: 35.0 ft
Height: 17.21 ft

Zero Fuel Weight: 24,600 lbs
Fuel Weight: 33,300 lbs
Takeoff Gross: 57,900 lbs

Cruise Mach: 3.2
Cruise Alt: 92 kft
Radius: 1,370 NM



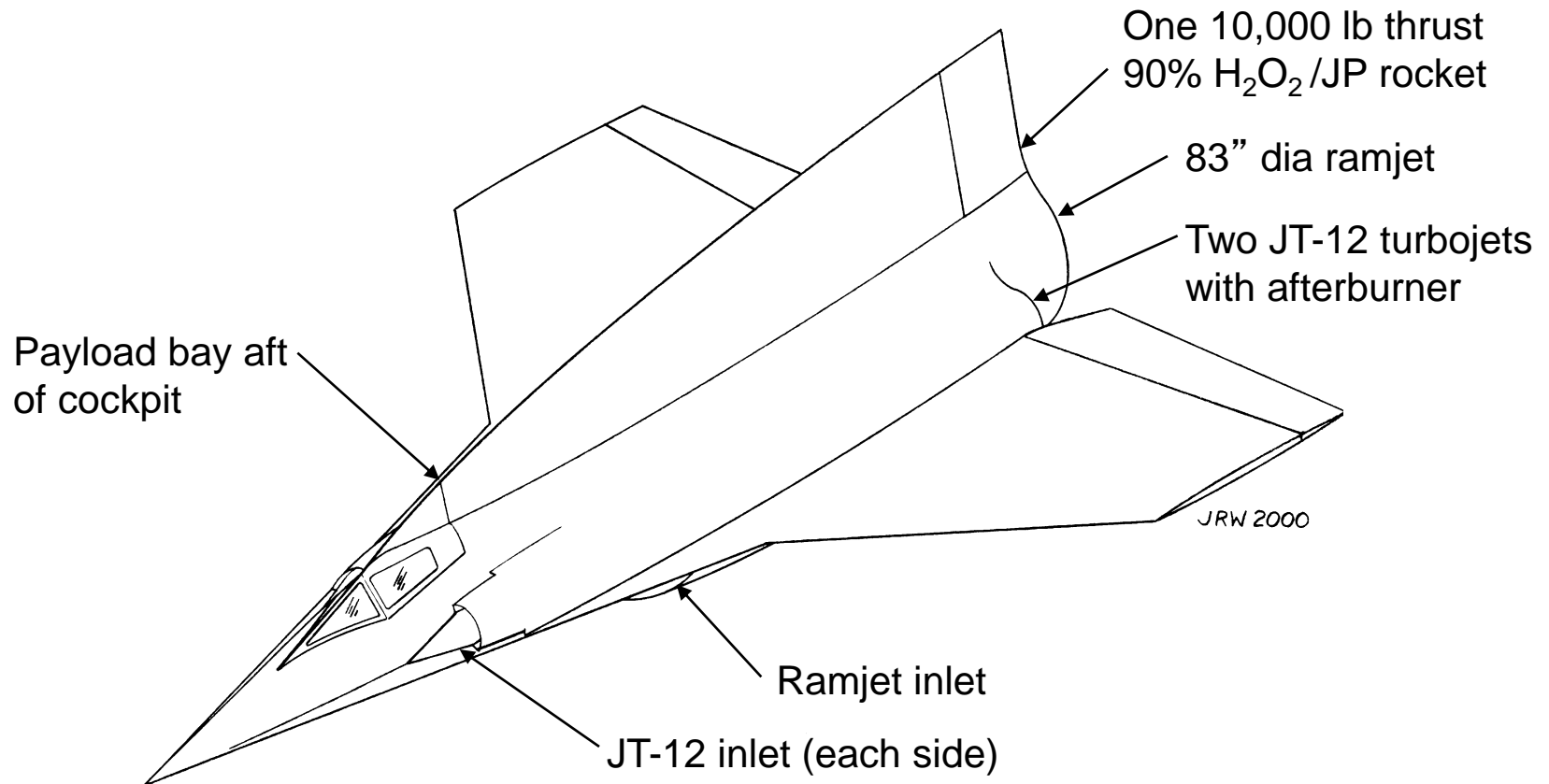
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A-5

December 1958

Length:	46.0 ft	Zero Fuel Weight:	18,500 lbs	Cruise Mach:	3.2
Span:	32.5 ft	Fuel Weight:	31,820 lbs	Cruise Alt:	90 kft
Height:	16.92 ft	Takeoff Gross:	50,320 lbs	Radius:	1,557 NM



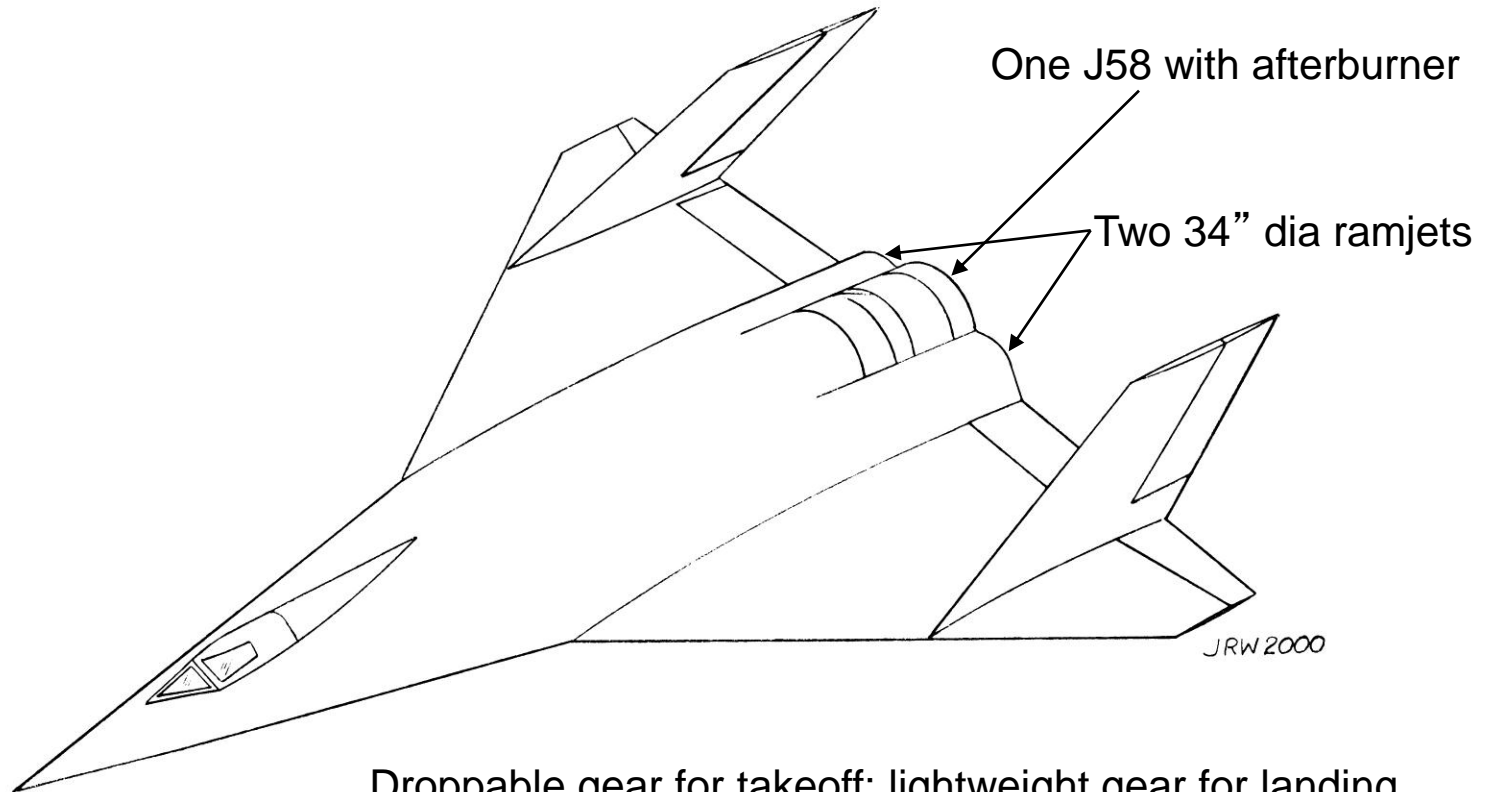
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A-6

January 1959

Length:	64.0 ft	Zero Fuel Weight:	29,200 lbs	Cruise Mach:	3.2
Span:	47.2 ft	Fuel Weight:	33,750 lbs	Cruise Alt:	90 kft
Height:	22.85 ft	Takeoff Gross:	62,950 lbs	Radius:	1,287 NM



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A-4 through A-6 Design Studies

- Goal: self-launch with minimum radar cross section
- Approach:
 - Small physical size
 - Vertical surfaces hidden above wing
 - Blended wing/fuselage configuration
- These vehicles employed combinations of turbojet, ramjet, and rocket propellant
- Design integration extremely challenging, particularly from the standpoint of fuel accommodation (in every conceivable space)
- None of the A-4 through A-6 design concepts met required range

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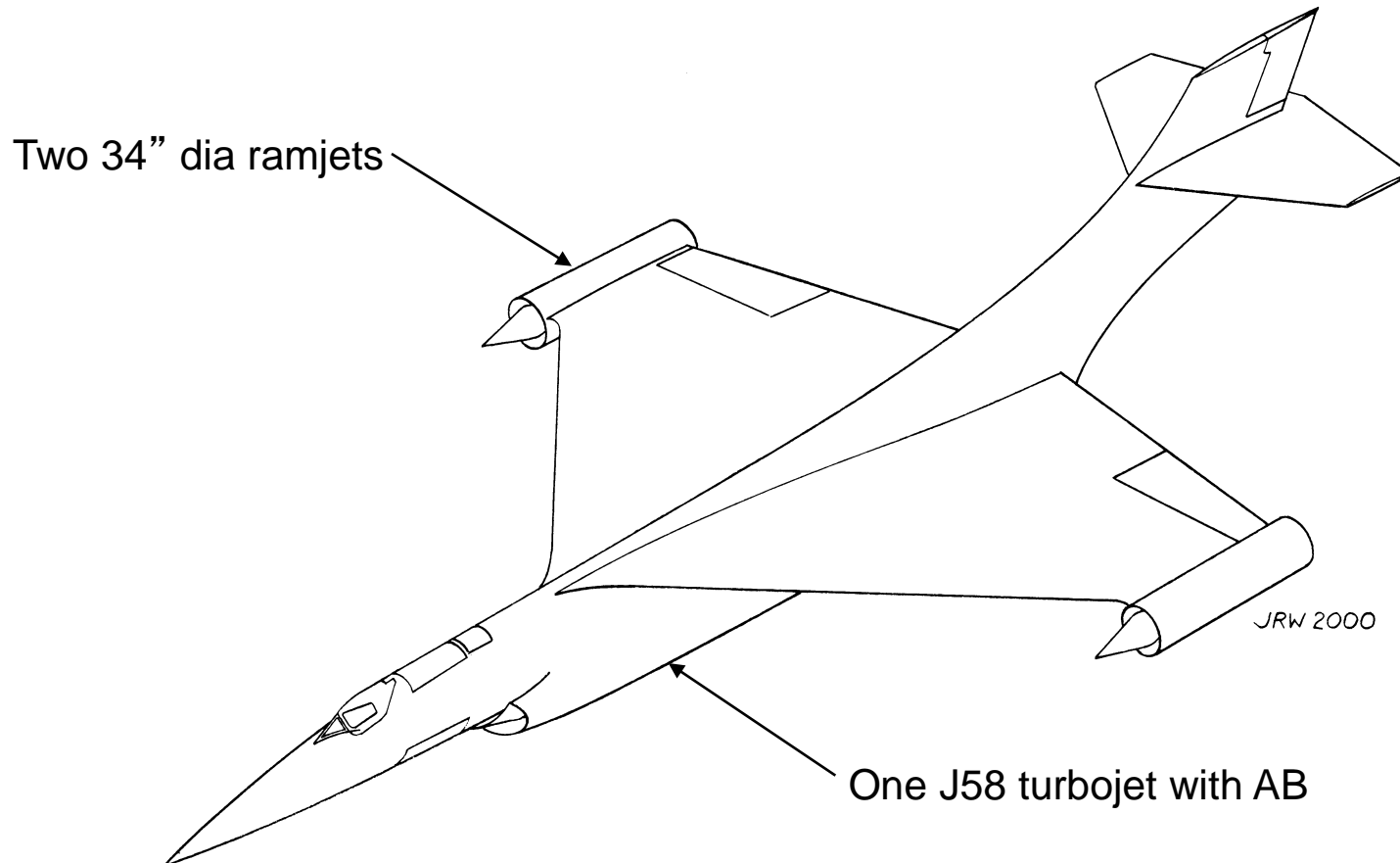
A-7

January 1959

Length: 93.75 ft
Span: 47.5 ft
Height: 22.85 ft

Zero Fuel Weight: 27,200 lbs
Fuel Weight: 43,700 lbs
Takeoff Gross: 70,900 lbs

Cruise Mach: 3.2
Cruise Alt: 91.5kft
Radius: 1,637 NM



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A-7 through A-9 Design Studies

- Refocus on maximum performance at expense of radar cross section
- Approach:
 - Similar configuration to A-1 and A-2, but smaller dimensions
 - One J58 afterburning turbojet plus two 34” dia. Marquardt XPJ-59 ramjets burning JP-150 only (no HEF)
- Results:
 - Poor mission radius (1,637 NM versus 2,000 NM for A-2)
 - Poor mid-mission altitude (91,500 ft versus 100,000 ft for A-2)

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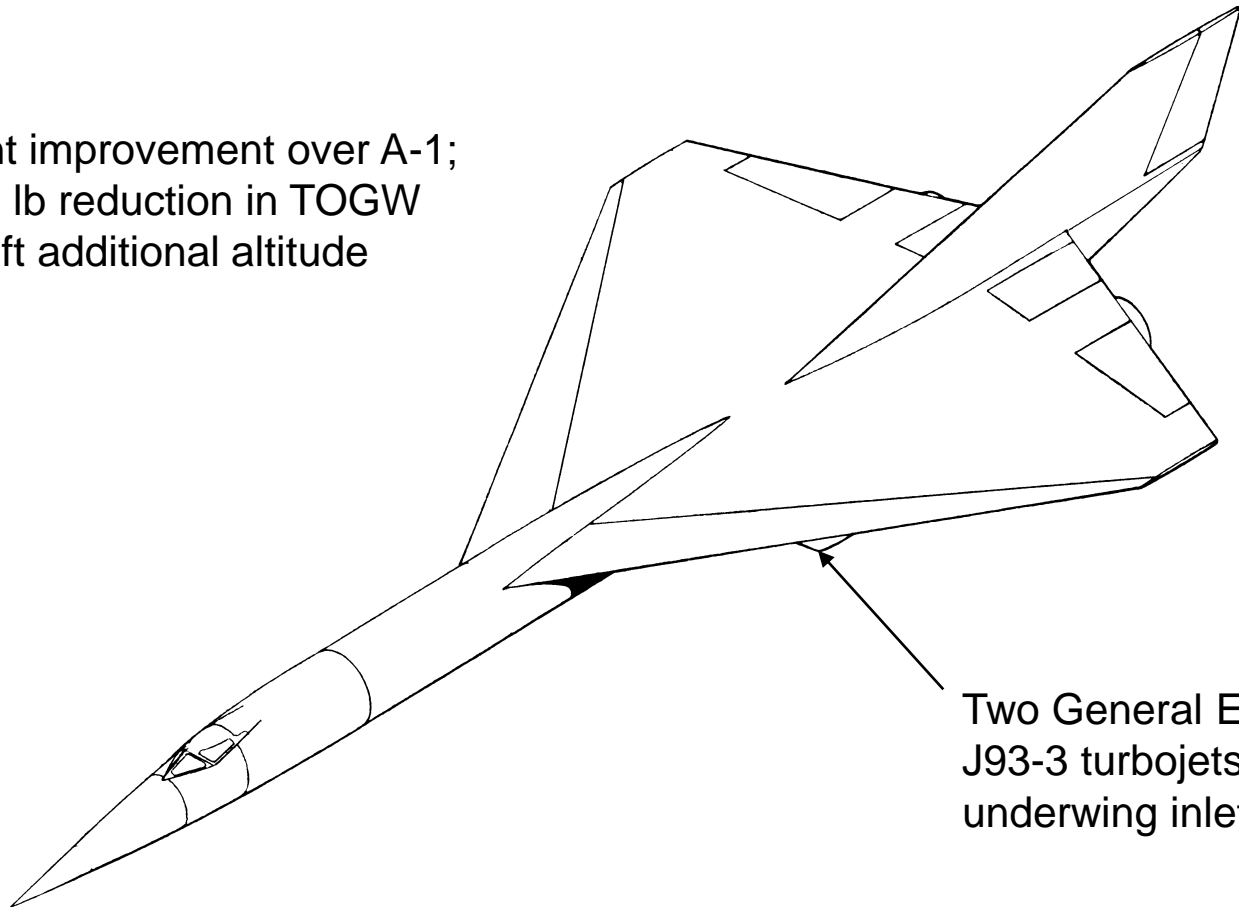
A-10

February 1959

Length:	109.5 ft	Zero Fuel Weight:	33,300 lbs	Cruise Mach:	3.2
Span:	46.0 ft	Fuel Weight:	52,700 lbs	Cruise Alt:	90.5 kft
Height:	19.25 ft	Takeoff Gross:	86,000 lbs	Radius:	2,000 NM

Significant improvement over A-1;

- 18,000 lb reduction in TOGW
- 2,500 ft additional altitude



Two General Electric
J93-3 turbojets; 2-D
underwing inlets

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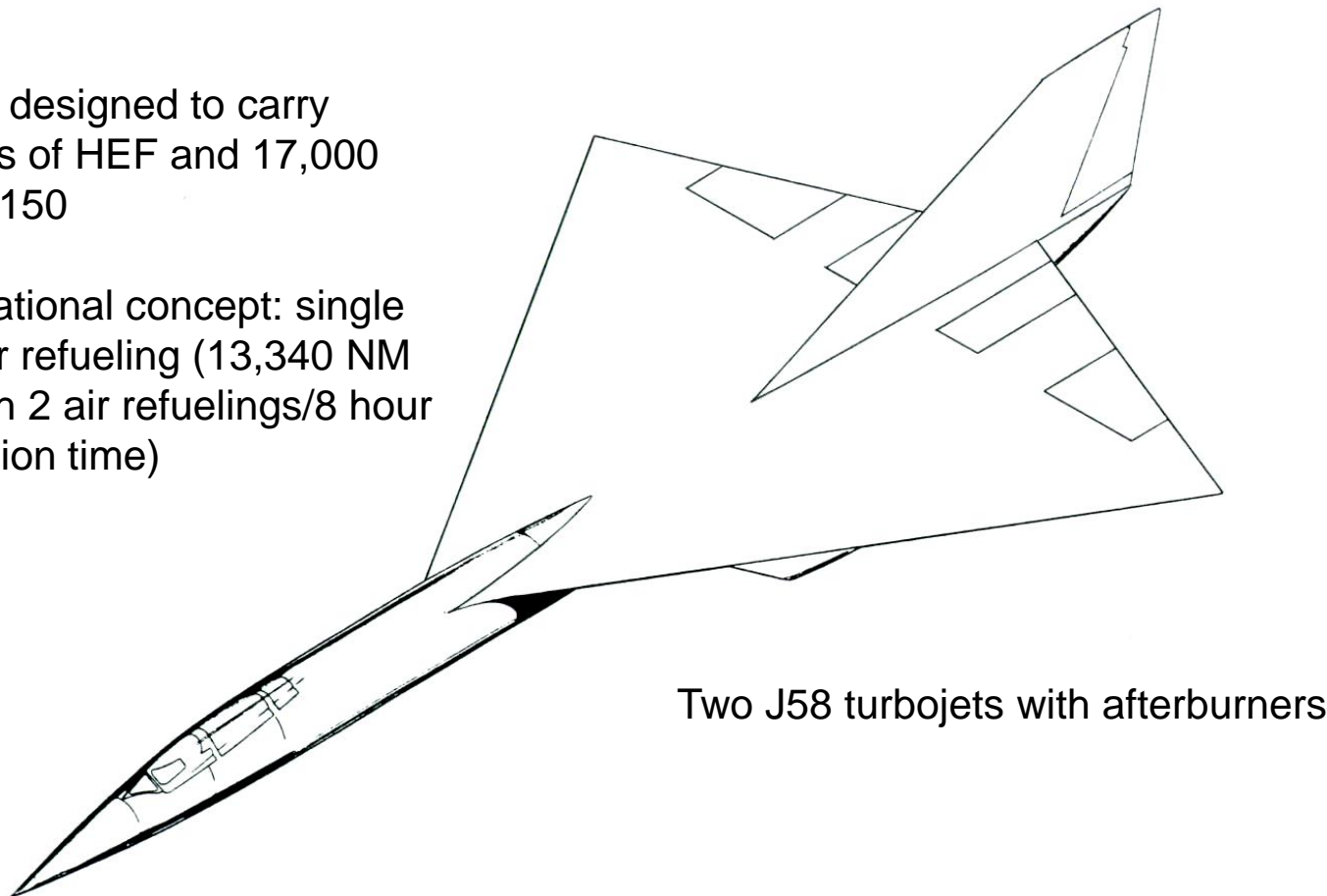
A-11

March 1959

Length:	116.67 ft	Zero Fuel Weight:	36,800 lbs	Cruise Mach:	3.2
Span:	56.67 ft	Fuel Weight:	55,330 lbs	Cruise Alt:	93.5 kft
Height:	21.03 ft	Takeoff Gross:	92,130 lbs	Radius:	2,000 NM

Originally designed to carry
31,000 lbs of HEF and 17,000
lbs of JP-150

Key operational concept: single
base + air refueling (13,340 NM
range with 2 air refuelings/8 hour
total mission time)



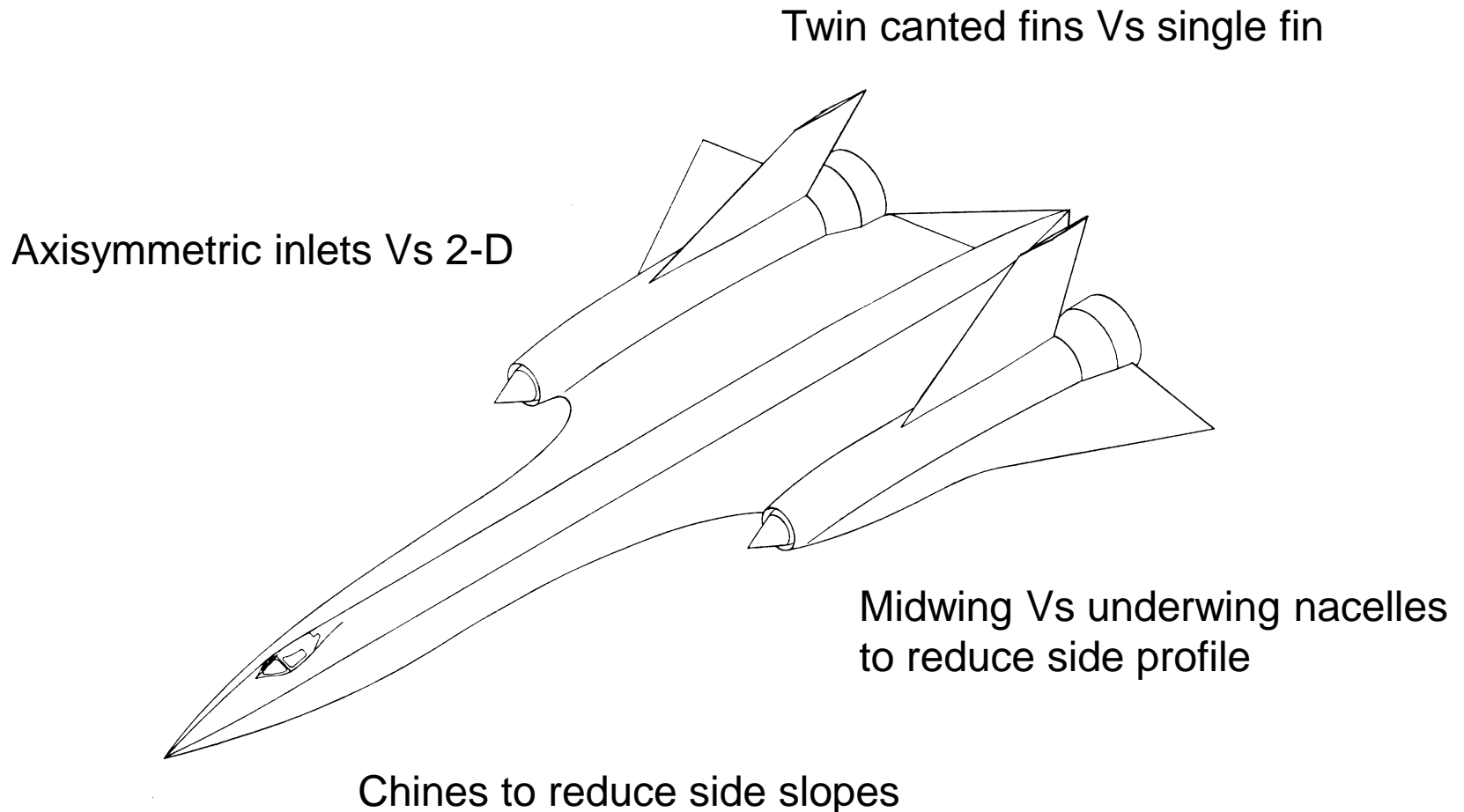
Two J58 turbojets with afterburners

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Initial A-12 Configuration

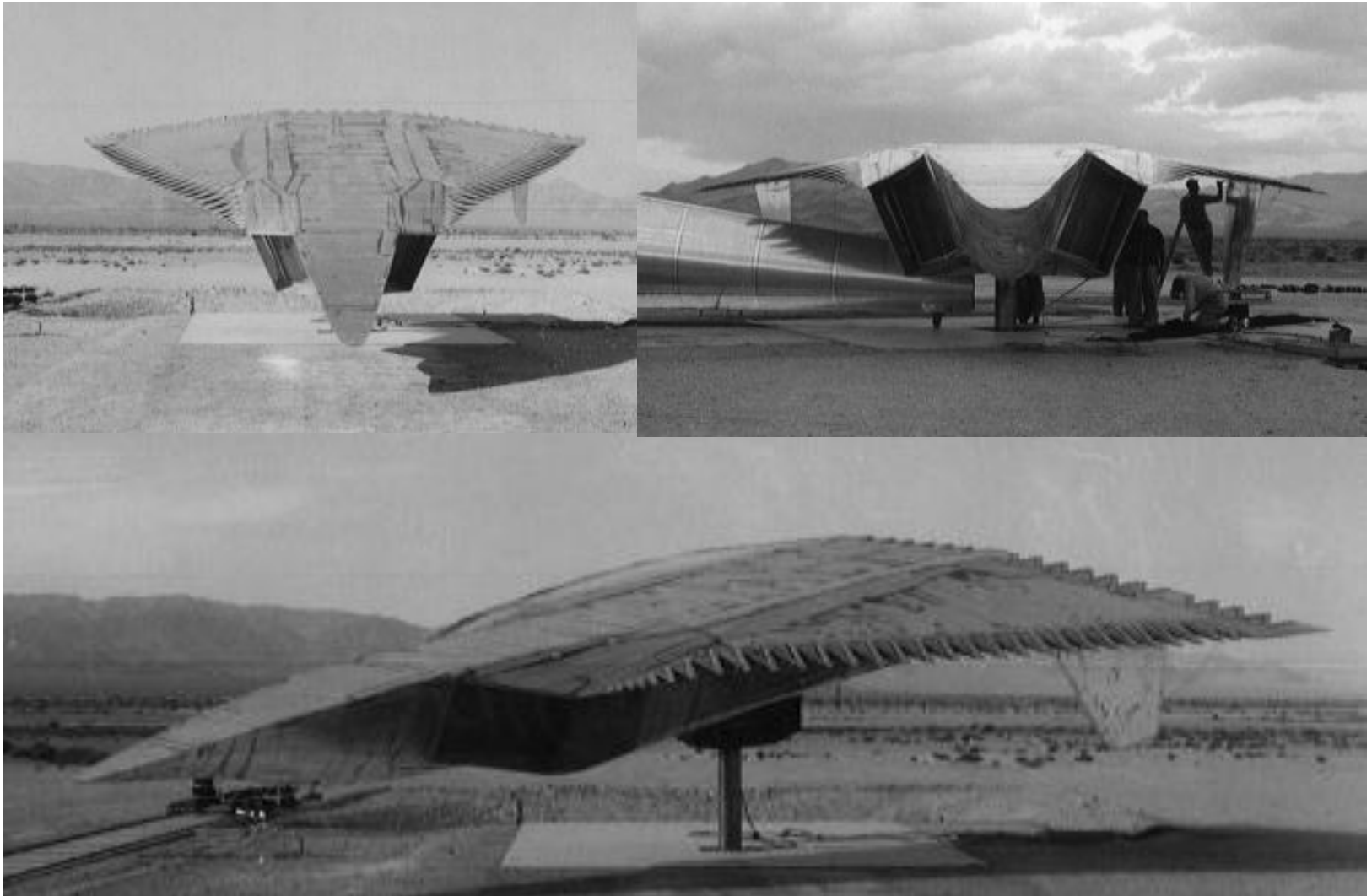
July 1959



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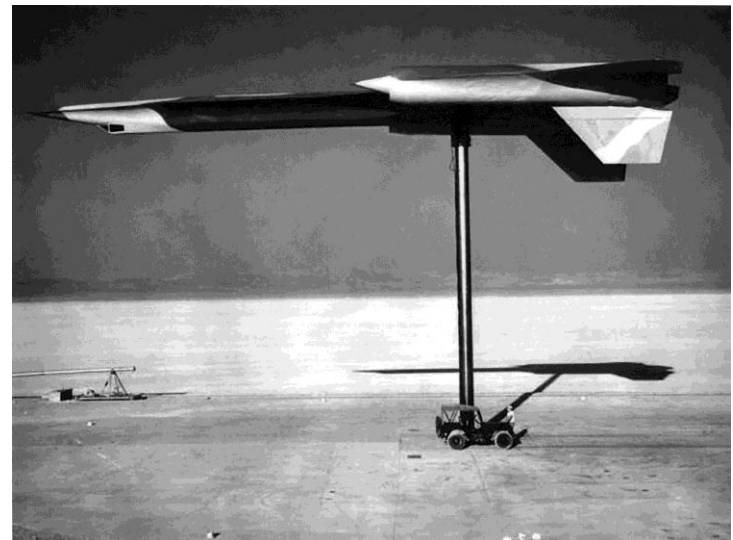
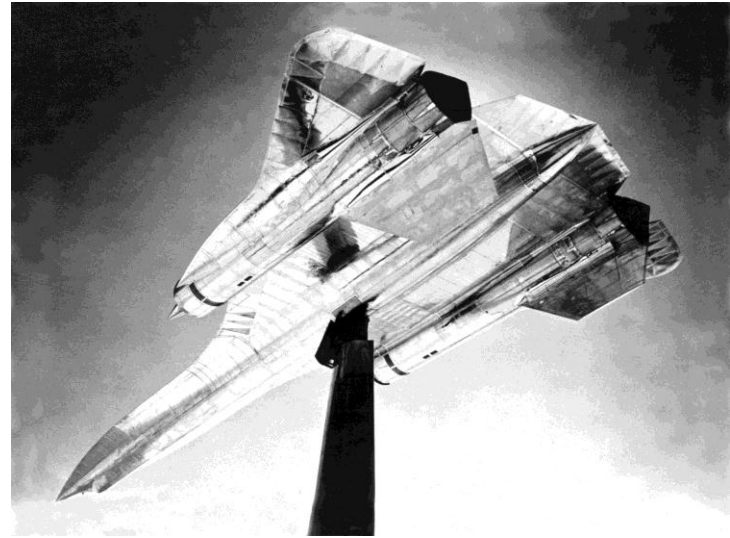
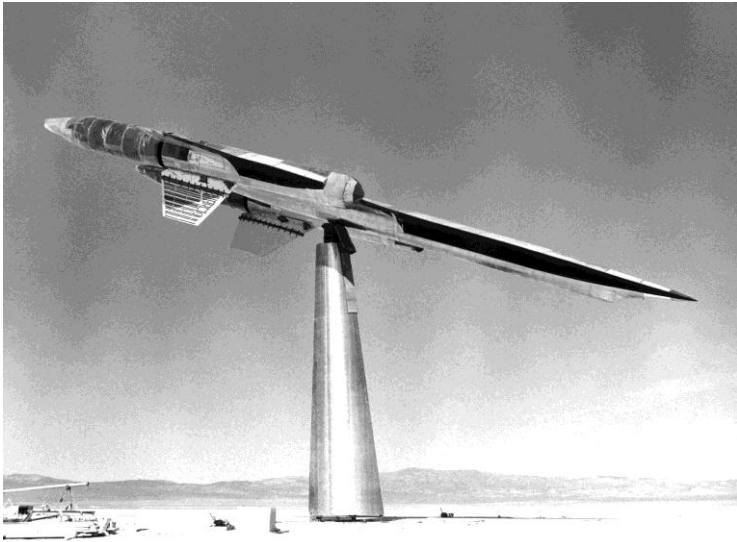
KINGFISH Pole Model



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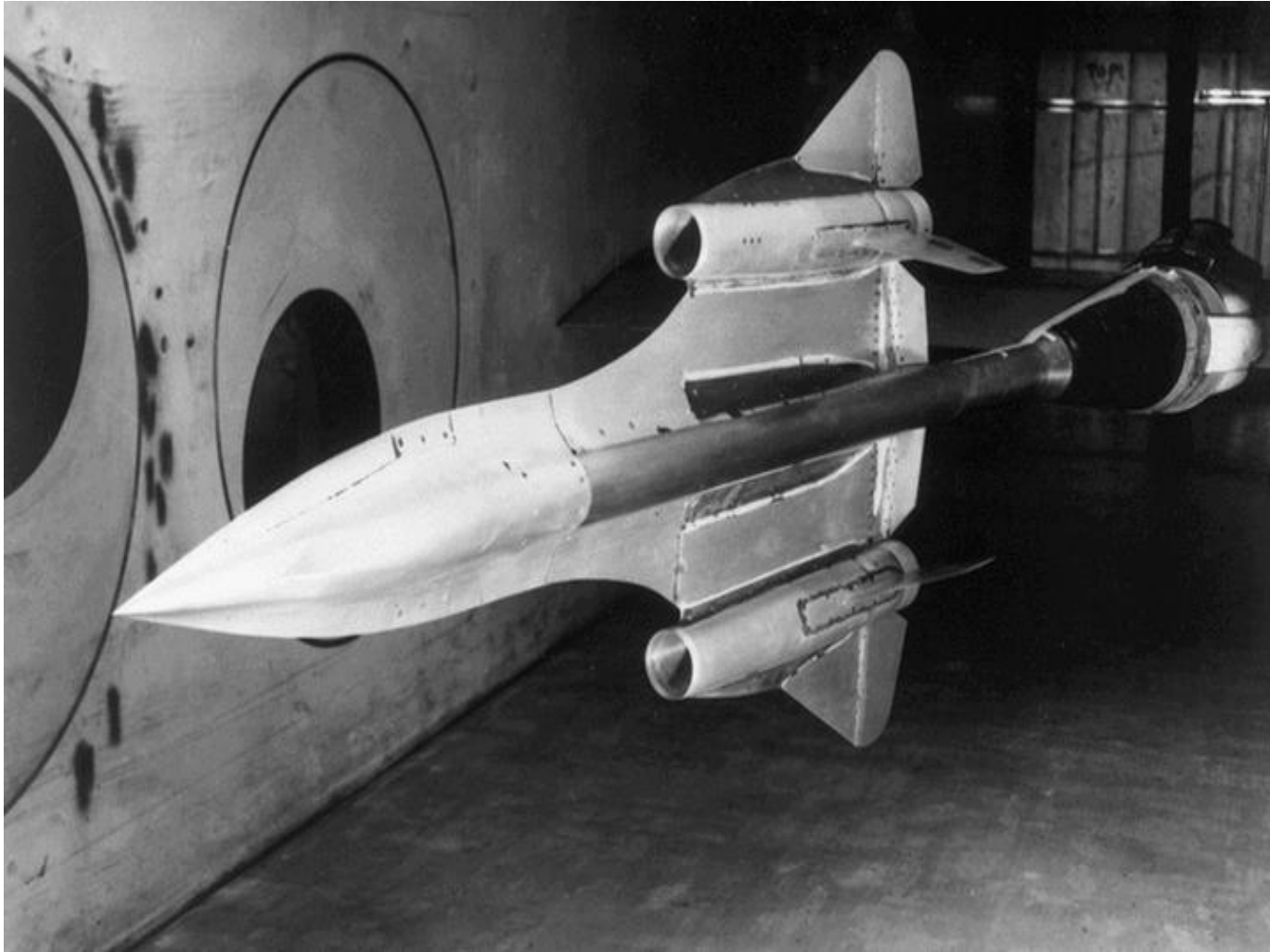
A-12 Pole Models



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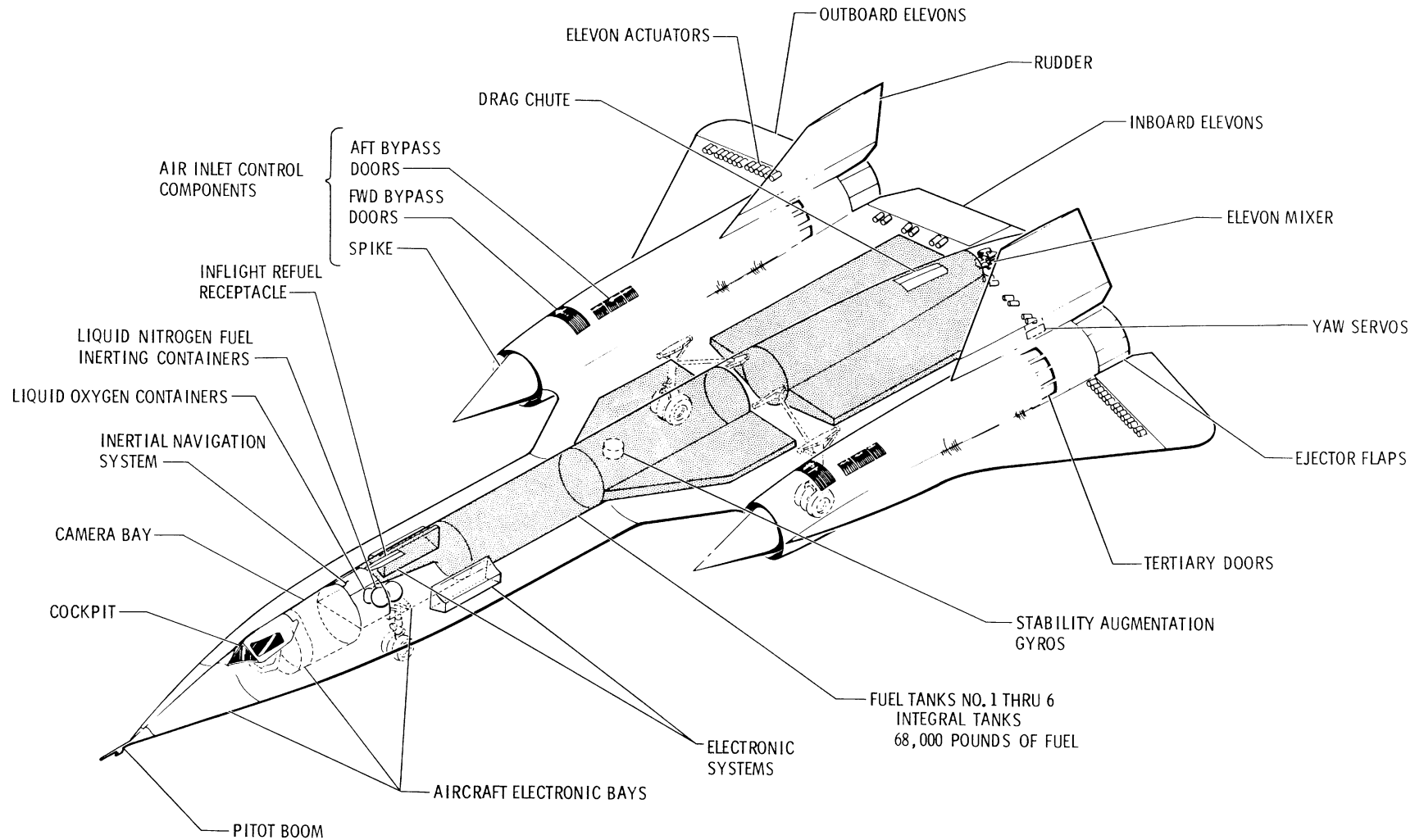
A-12 Wind-Tunnel Model



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A-12 Design Features



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A-12 OXCART



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YF-12A KEDLOCK



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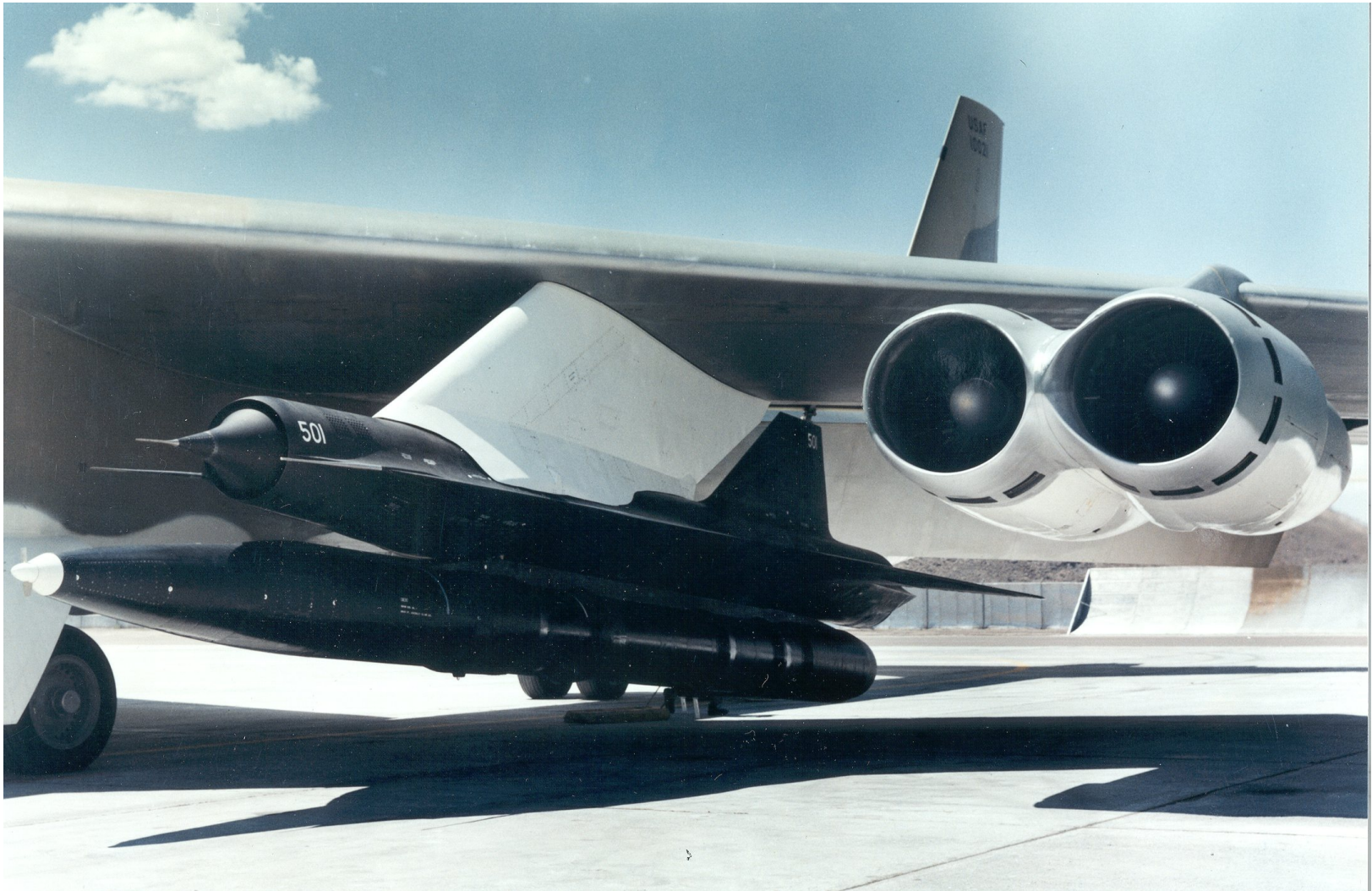
MD-21 TAGBOARD



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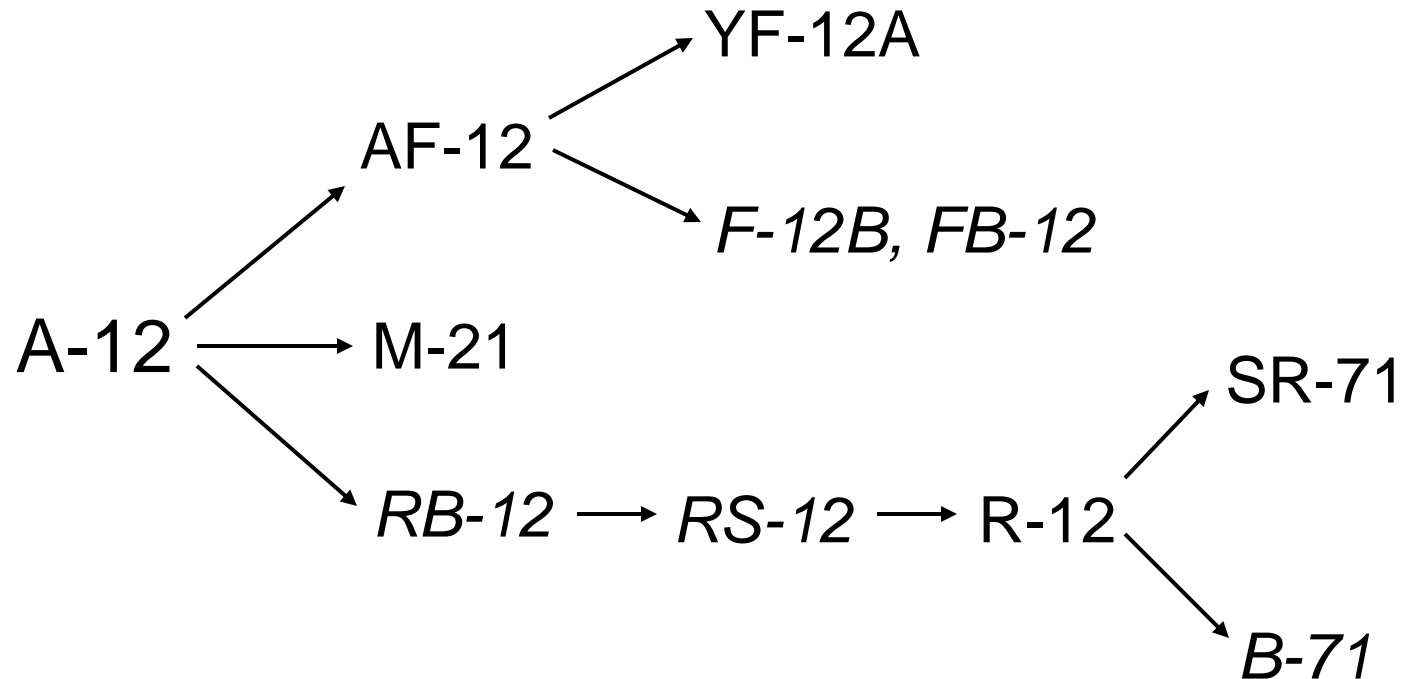
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D-21B SENIOR BOWL



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A-12 INITIATED "BLACKBIRD" FAMILY



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Lockheed Blackbird Assembly Line



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SR-71 SENIOR CROWN



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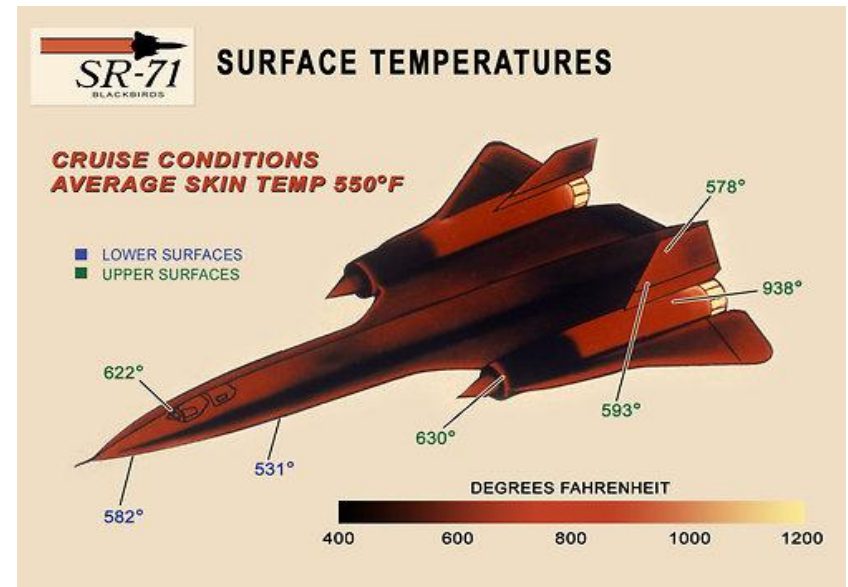
Blackbird Structure

**Titanium
Stainless Steel
Hastelloy X
René 41
Astralloy
Waspalloy
Composites**

Surface Temperatures

Average: 462-622 degrees F

Up to 1,050 degrees F on engine nacelle



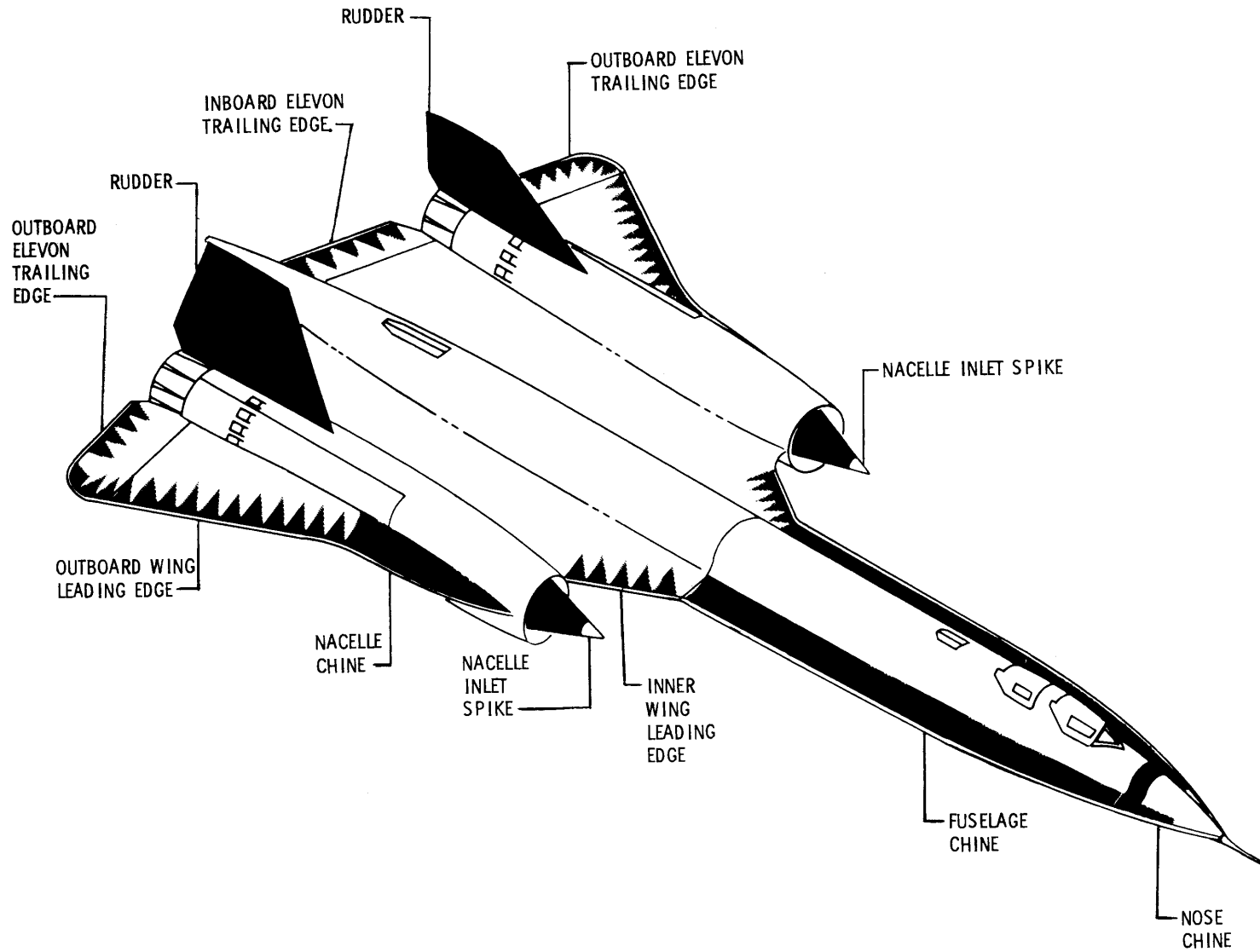
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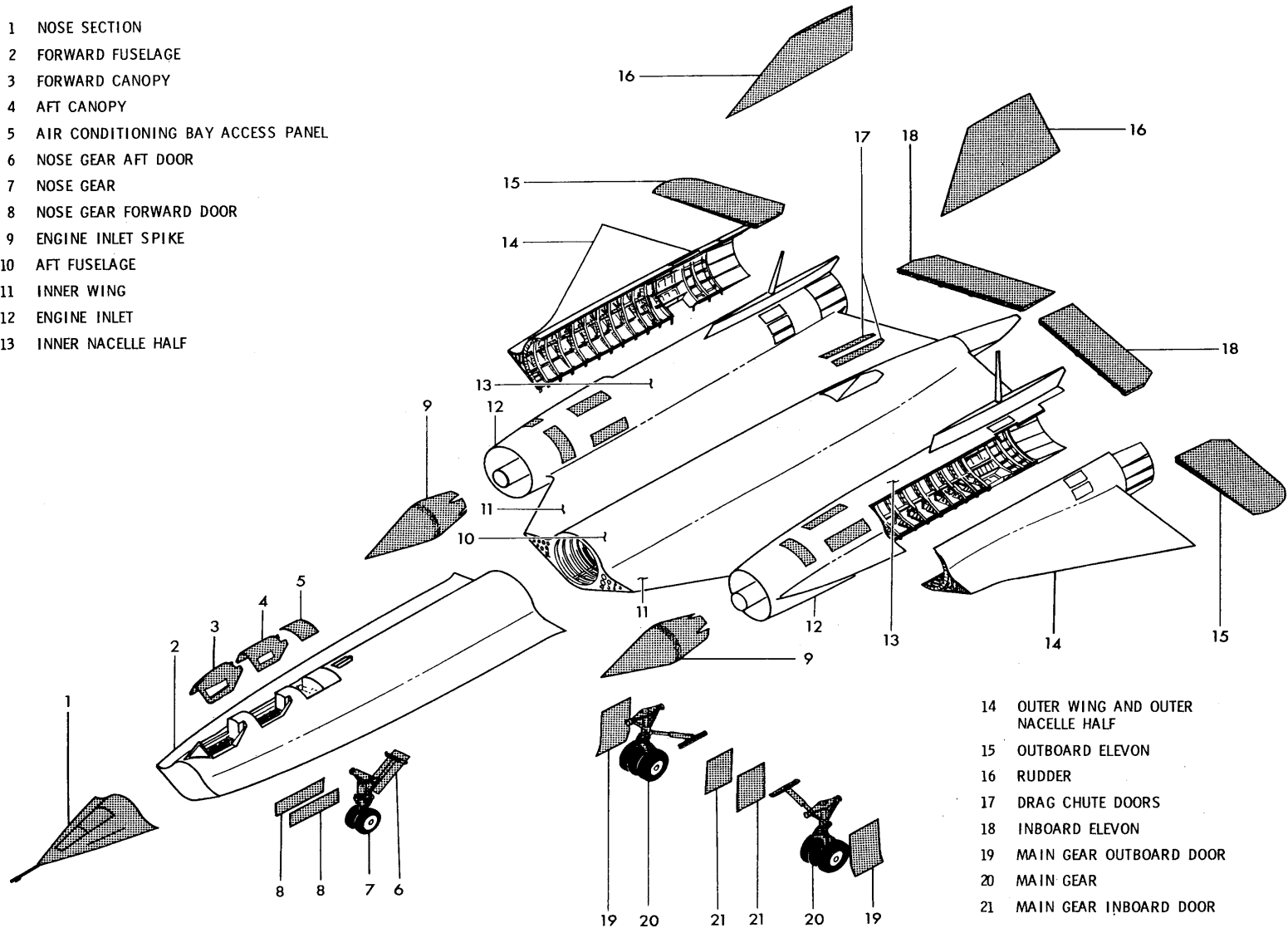
Blackbird Paint Schemes



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- 1 NOSE SECTION
- 2 FORWARD FUSELAGE
- 3 FORWARD CANOPY
- 4 AFT CANOPY
- 5 AIR CONDITIONING BAY ACCESS PANEL
- 6 NOSE GEAR AFT DOOR
- 7 NOSE GEAR
- 8 NOSE GEAR FORWARD DOOR
- 9 ENGINE INLET SPIKE
- 10 AFT FUSELAGE
- 11 INNER WING
- 12 ENGINE INLET
- 13 INNER NACELLE HALF

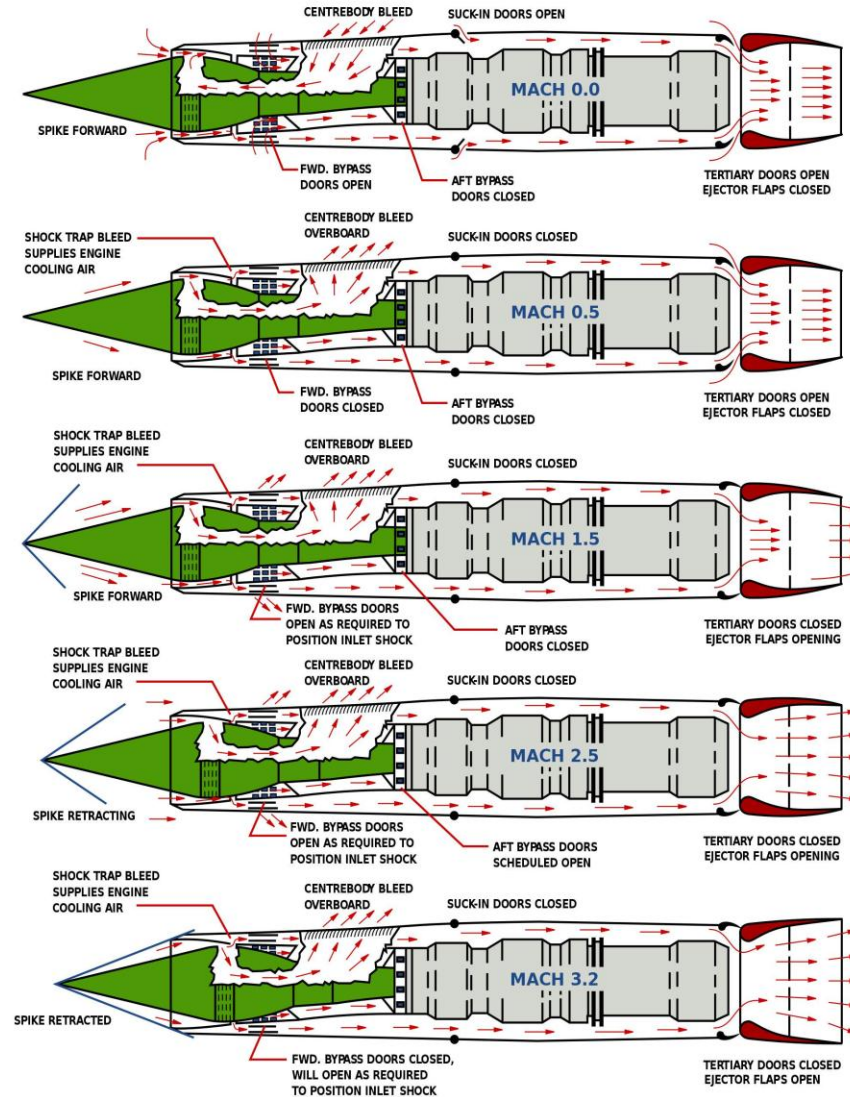


- 14 OUTER WING AND OUTER NACELLE HALF
- 15 OUTBOARD ELEVON
- 16 RUDDER
- 17 DRAG CHUTE DOORS
- 18 INBOARD ELEVON
- 19 MAIN GEAR OUTBOARD DOOR
- 20 MAIN GEAR
- 21 MAIN GEAR INBOARD DOOR

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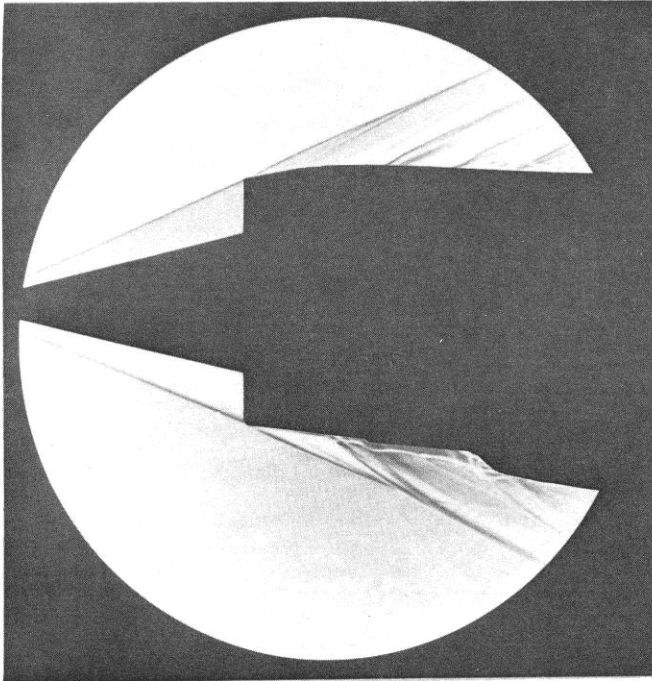
J58 Engine Operation



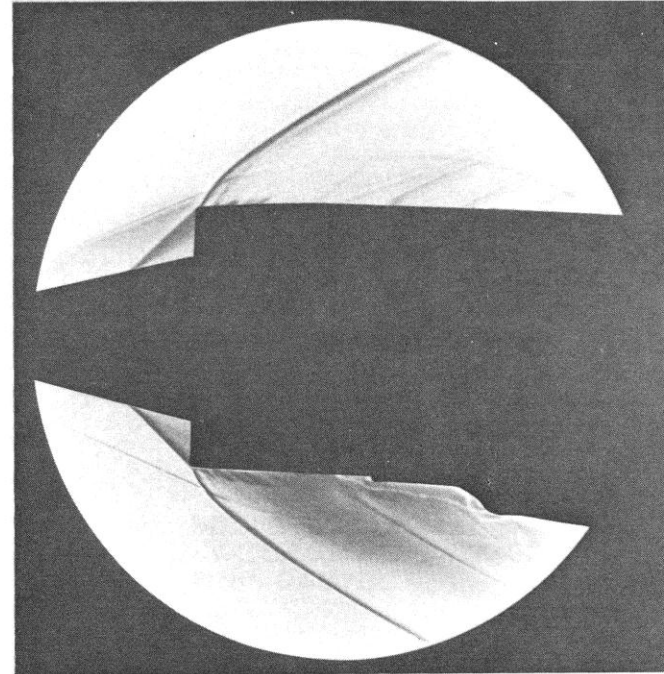
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INLET UNSTART



INLET STARTED



INLET UNSTARTED

Blackbird Performance

Fastest Flights:

YF-12A – Mach 3.14 (2,070 mph), USAF, official, 1 May 1965

A-12 – Mach 3.29 (2,171 mph), CIA, unofficial, 8 May 1965

SR-71A – Mach 3.32 (2,193 mph), USAF, official, 27 July 1976

Highest Flights:

YF-12A – 80,257 feet, USAF, official, 1 May 1965

SR-71A – 85,068 feet, USAF, official, 27 July 1976

SR-71A – 89,650 feet, USAF, unofficial, 1968 (Category II Test)

A-12 – 90,000 feet, CIA, unofficial, 14 August 1965

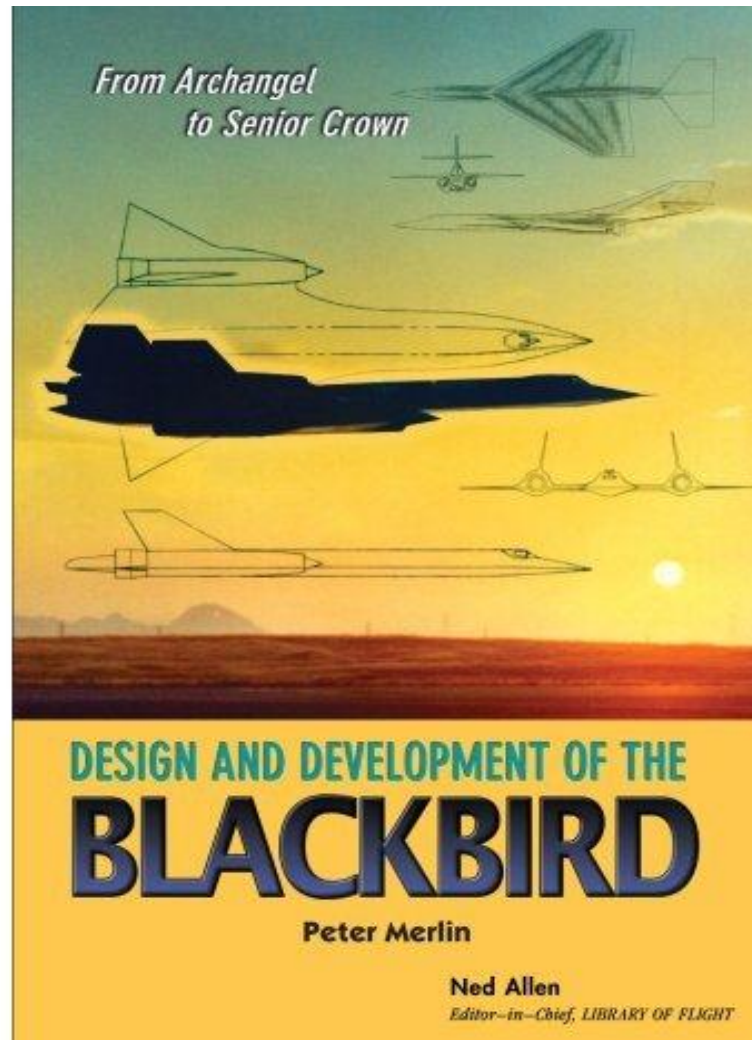
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NASA's Flying Laboratories



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